Space Weather Technical Forecast

Issued on Monday, 13 November 2023 at 00:29 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of G1/Minor Storms on Day 1 (13 Nov) due to CME effects. Chance of M-class flares, declining through the period. Active electron fluence probably easing.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low with only C-class flares in the last 24 hours. There are currently five sunspot regions on the disc. AR3483 in the northwest remains the largest region, perhaps with some minor magnetic complexity, however this is getting more difficult to assess as it starts to approach the limb. AR3486 in the south-centre disc has grown rapidly in recent hours, although this growth now seems to be stabilising. The other regions appear relatively stable in recent hours - but as with all regions approaching the west limb the analysis becomes more difficult, and for those closest to the limb their classification will be maintained as they rotate off the disc. No new Earth-directed CMEs have been observed in the past 24 hours.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by ACE and DSCOVR, showed a CME arrival around 12/0530 UTC. Speeds have been elevated to slightly elevated, jumping up to around 580 km/s after the CME arrival, but since easing below 500 km/s. Density was around average, but became above average after the CME arrival, peaking at 28 ppcc. The total magnetic field strength (Bt) was initially weak, becoming moderate as Earth entered the magnetic cloud of the CME. The north-south component (Bz) was weakly negative after the CME arrival, becoming moderately positive within the magnetic cloud, then rotating moderately negative just after 12/2200 UTC. The phi angle was variable. Geomagnetic activity was Quiet to Unsettled (Kp 1-3), but with an Active (Kp 4) interval 12/0600-0900 UTC.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at background levels. GOES16 high energy (greater than 2MeV) electron flux was at mostly high levels, peaking at 2640pfu at 12/0010 UTC, but declined to moderate levels after 12/1830 UTC. The associated 24-hour fluence was above the Active (1e8 integrated pfu) threshold on a declining trend. The fluence observation at 13/0000UTC was 1.31e8 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Four of the five sunspot regions currently on the disc are due to rotate off in the coming days. There is a gradually declining chance of M-flares occurring through the period, becoming a slight chance by Day 4 (16 Nov).

Solar Wind / Geomagnetic Activity: A CME arrived at Earth around 12/0530UTC. Impacts from this have been fairly muted so far, but there is a possibility of some slightly increased geomagnetic activity in the coming hours. A faint and slow CME was observed leaving the Sun late on 10 Nov. There is a chance of a glancing blow on Day 3 (15 Nov) but with very limited impacts expected. There may be a weak HSS from CH68/+ currently, although this has been largely swamped by the CME. However, effects from this feature may prolong slightly elevated wind speeds into Day 2 (14 Nov).

Overall, geomagnetic activity may be Unsettled to Active with a chance of isolated G1/Minor Storm intervals at first due to CME effects. This gradually easing through Day 1 (13 Nov) to be Quiet to Unsettled for much of the rest of the period. Active intervals are possible on Day 3

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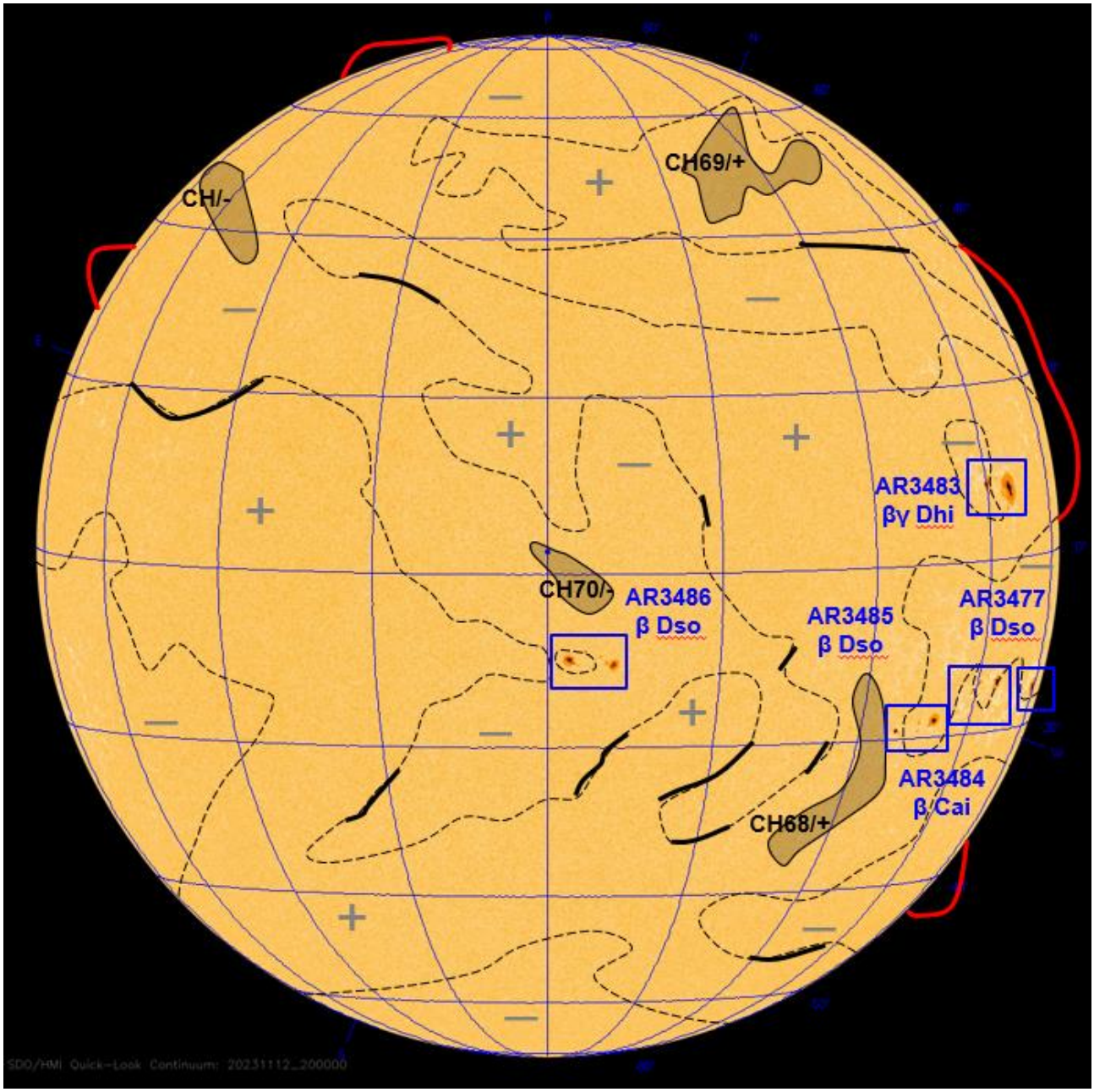
should we see a glancing CME arrival.
Energetic Particles / Solar Radiation: There is a slight chance of S1 or greater radiation storm conditions should any of the western hemisphere sunspot groups produce significant flares during the period. This risk will wane through the period as these sunspots rotate well away from the western limb.
High energy electron flux (greater than 2MeV) is likely to gradually decline in the coming days, with the currently Active (1e8 integrated pfu) fluence also likely to ease. Confidence is low in the timing of any decrease.

Figure 1. Solar Analysis Valid 12/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The full halo CME which left the Sun on 09 Nov arrived at Earth at 12/0530UTC. Impacts from this have been fairly muted so far due to a mostly northward directed magnetic field, but a recent switch to a southward directed field may indicate the likelihood of some slightly increased geomagnetic activity in the coming hours.

A faint and slow CME was observed leaving the Sun late on 10 Nov. The source region of this CME appears to be an eruption in the southwest quadrant in the vicinity of the trio of sunspots (AR3477, AR3484 and AR3485). Modelling suggests that the bulk of the CME will miss ahead of Earth's orbit, however there is a chance of a glancing blow on Day 3 (15 Nov) but with very limited impacts expected.

The current CME effects may be bolstered somewhat by a weak HSS from CH68/+, although this has been largely swamped by the CME. However, effects from this feature may prolong slightly elevated wind speeds into Day 2 (14 Nov). A further very small feature, CH70/-, is unlikely to give significant impacts at Earth.

Overall, geomagnetic activity may be Unsettled to Active with a chance of isolated G1/Minor Storm intervals at first due to CME effects. This gradually easing through Day 1 (13 Nov) to be Quiet to Unsettled for much of the rest of the period. Active intervals are possible on Day 3 should we see a glancing CME arrival.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	25	1	5	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
11/0633	Partial	Near AR3480, AR3484 and AR3485	Central SW	378 km/s	15/1200 UTC	Low confidence. Limited impact expected.

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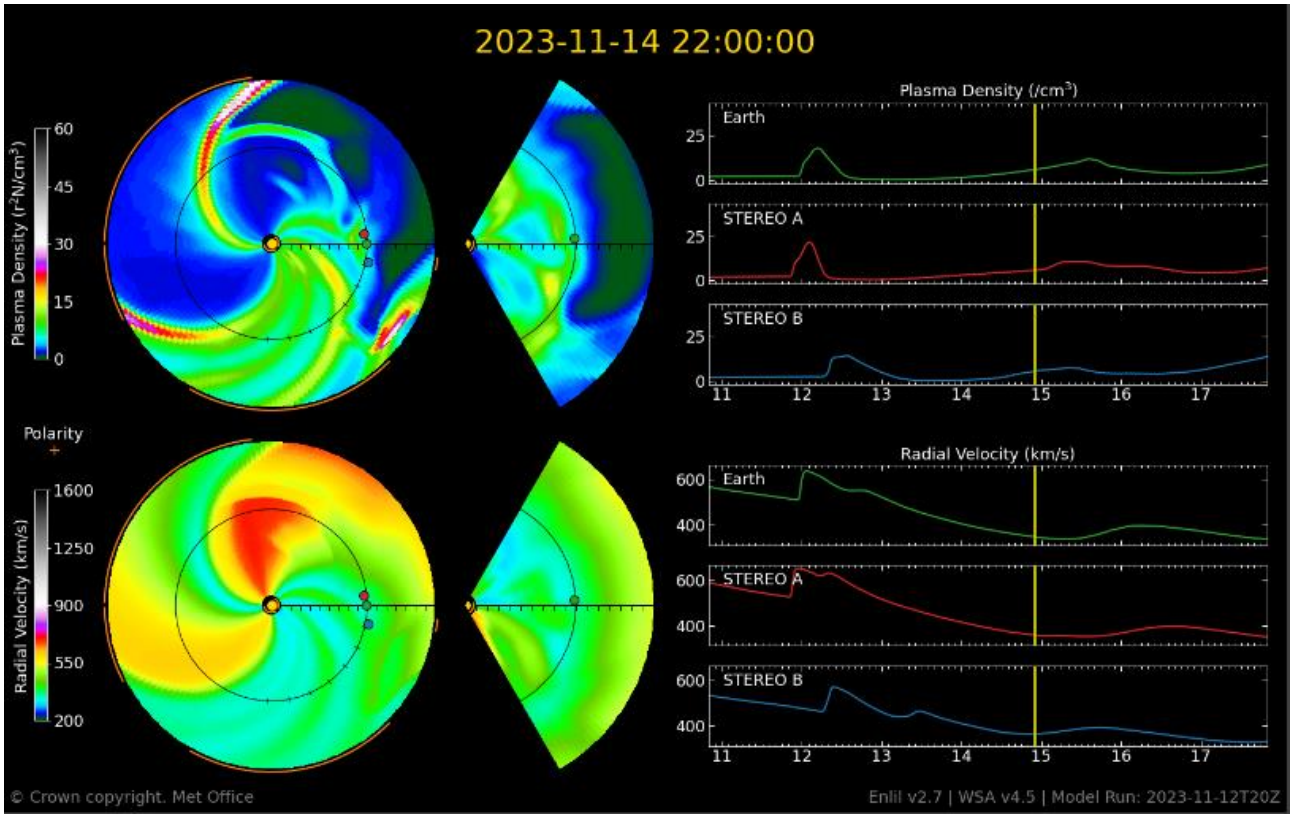
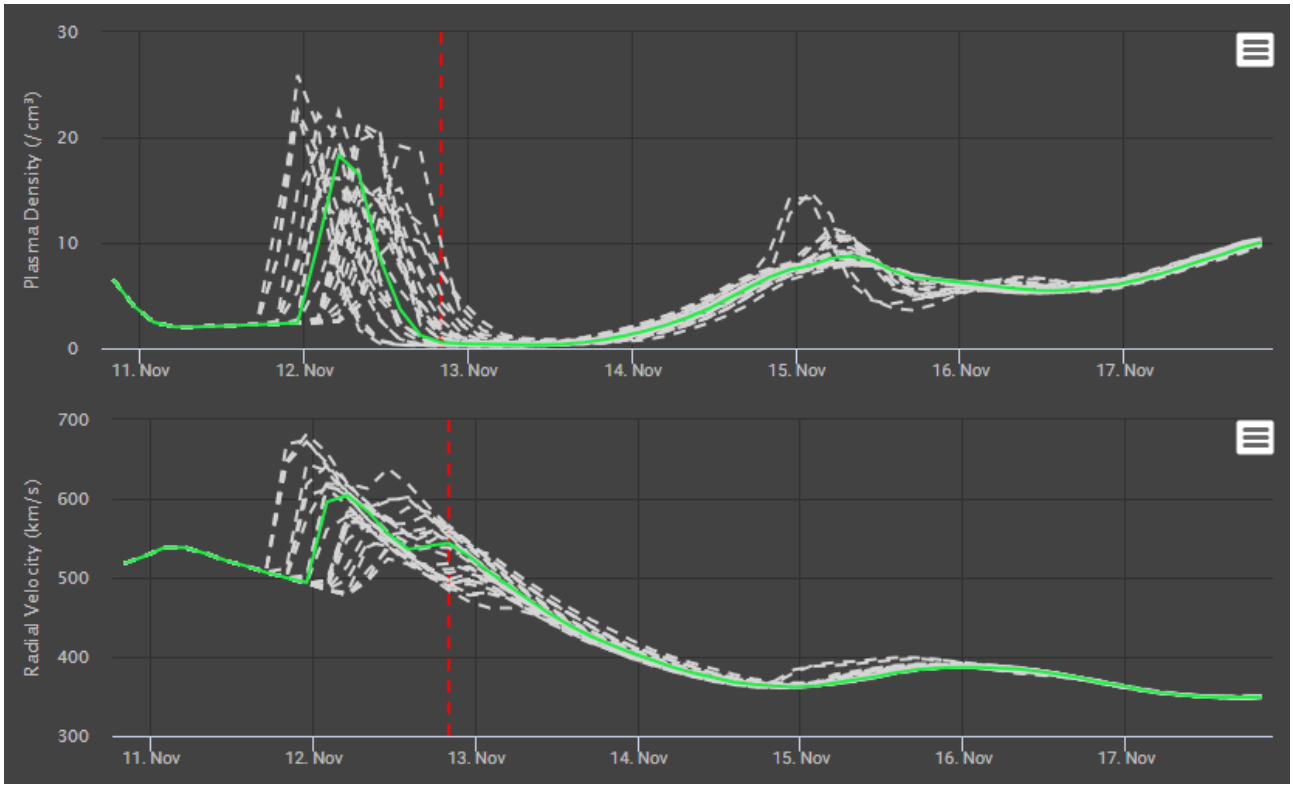
Figure 2: MOSWOC Enlil and ensemble, showing a low risk of a glancing CME blow on 15 November.





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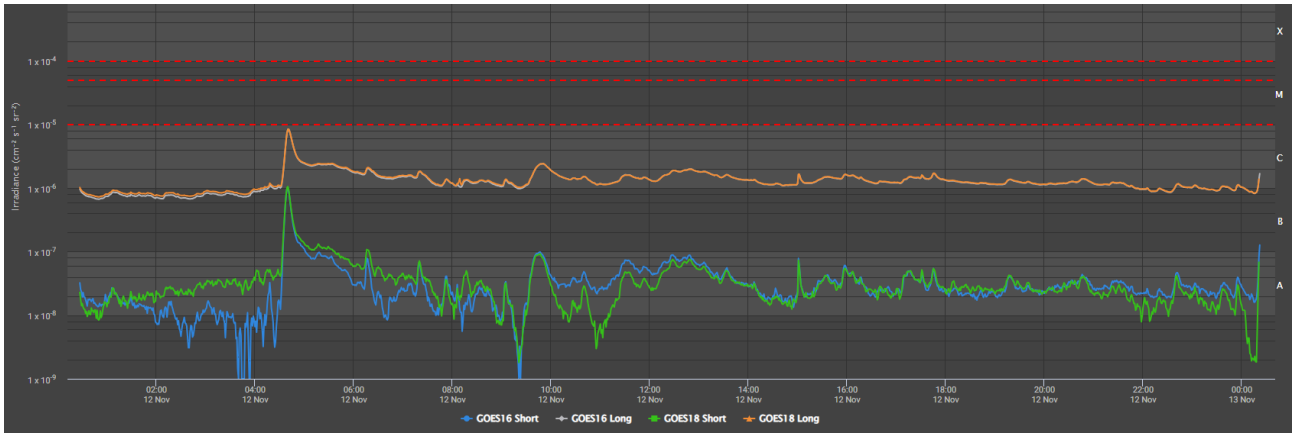
Radio Blackouts - X-Ray Flares:
There are currently five sunspot regions on the disc. AR3483 (Dhi/Beta-Gamma) in the northwest remains the largest region, perhaps with some minor magnetic complexity, however this is getting more difficult to assess as it starts to approach the limb. AR3486 (Dso/Beta) in the south-centre disc has grown rapidly in recent hours, although this growth now seems to be stabilising. The other regions appear relatively stable in recent hours - but as with all regions approaching the west limb the analysis becomes more difficult, and for those closest to the limb their classification will be maintained as they rotate off the disc.

In terms of the risk from the current visible sunspot regions, AR3477 should depart later on Day 1 (13 Nov), followed by AR3483 and AR3484 late on Day 2 (14 Nov) and AR3485 late on Day 3 (15 Nov). This should significantly reduce the risk of M-class flares, although further sunspot development is possible at any time. Far-sided soundings, persistence and flux looping all suggest limited contributions from any returning regions over the eastern limb during the period.

All this taken into account, there is a gradually declining chance of M-flares occurring through the period, becoming a slight chance by Day 4 (16 Nov).

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	35	30	20	15
Very Active	R3 to R5 X Class	No	5	5	2	2

Figure 3: X-ray trace at GOES16 and GOES18, with only C-class flares in the last 24 hours.



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Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux observed by GOES16 is at background levels. There is considered to be a slight chance of S1 or greater radiation storm conditions during the period, owing to the various sunspot regions currently located in the western hemisphere. Probabilities then begin to wane later in the period as these regions rotate well away from the west limb.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	2
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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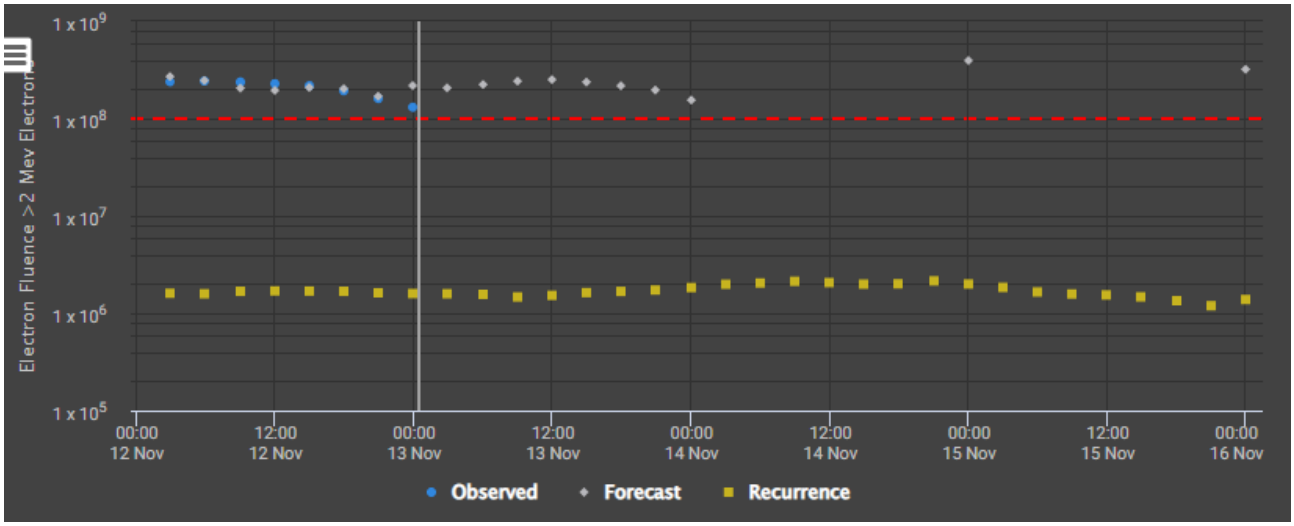
High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) has been at High levels over recent days in response to the fast wind from CH67/-. The 09 Nov CME which arrived around 12/0530 UTC has so far given limited geomagnetic response, meaning the usual electron flux dropout with a CME arrival has not occurred. The electron flux has declined very slowly over recent hours, however. There is low confidence in the behaviour of the electron flux in the coming days, but a continued slow decline seems most likely in the absence of geomagnetic activity. However, should we see an increase in geomagnetic activity then electron flux may drop off more sharply.

Active (1e8 integrated pfu) electron fluence is also likely to gradually decline over the coming days, but with low confidence in the timing of any reduction. However, MOSWOC REFM is suggesting Active fluence may continue through the next three days - this is perhaps an overestimate, but cannot be completely discounted.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	Yes	100	50	30	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 4: MOSWOC REFM showing an above Active trend through the next three days. This may be an overestimate.



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